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REMARKS

Claim 35 is amended. Claims 35-74 are pending in the application.

Claim 42 stands objected to under 35 CFR 1.75(c) as being of improper dependent form for failing to further limit the subject matter of a previous claim. The Examiner notes that the recitation in claim 42 of forming a third layer in a second PVD chamber has already been recited in base claim 35. Applicant has amended independent claim 35 to remove the recitation of forming a third layer in a second PVD chamber. The claim 42 recited forming a third layer in the second PVD chamber further limits the subject matter of amended claim 35 and claim 42 therefore properly depends from amended base claim 35. Accordingly, applicant respectfully requests withdrawal of the 37 CFR 1.75(c) objection to claim 42 in the Examiner's next action.

Claims 35-48 and 58-74 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. First, the Examiner states that independent claim 35 and each of its dependent claims are rendered indefinite due to broad claim language followed by narrow language within the same claim. The Examiner states that the claim 35 recitation of a temperature not going below about 360 °C at lines 7-9 , is followed by a recitation in lines 11 and 12 of an outer most portion being at least about 360 °C, and states that the second recitation is a narrower statement of the range limitation recited in lines 7-19. Applicant disagrees.

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Claim 35 recites depositing at least an outermost portion of a first layer at a first deposition temperature of at least 400 °C (lines 5 and 6), and recites that after the physical vapor depositing of the first layer and without letting the outermost portion of the first layer cool below 360 °C, physical vapor depositing titanium or a titanium alloy (lines 7-10). Claim 35 further recites that the titanium or titanium alloy is physical vapor deposited while at least an outer portion of the first layer is at a temperature of at least about 360 °C (Lines 9-12). Applicant notes that the recitation at lines 7-10 indicates that the outermost portion of the first layer is not allowed to cool prior to physical vapor deposition of titanium while the recitation at lines 9- 12 indicates that the outermost portion of the first layer is at least 360° C during the physical vapor depositing of titanium. The second recitation therefore does not claim a narrower range limitation of the first recitation. Accordingly, independent claim 35 is not rendered indefinite due to a broad range limitation together with a narrow range limitation in the same claim.

Second, the Examiner states that independent claim 35 is not particularly clear since lines 9-10 recite depositing at least one of elemental titanium or a titanium alloy while later in the same claim (lines 13 and 16) only recites titanium. The Examiner further states that the titanium recited in lines 13 and 16 of claim 35 limits the recited titanium or titanium alloy recited in lines 9-10 and that because line 13 recites only titanium, the alloy recited in line 13 is between aluminum and titanium and is not clearly drawn to a titanium alloy and

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aluminum. Applicant notes that when read in its entirety claim 35 is not rendered unclear.

Claim 35 recites physical vapor depositing at least one of elemental titanium or a titanium alloy on a first layer and forming therefrom a second layer comprising an alloy of titanium and aluminum from the first layer, and that essentially all the titanium alloys with the aluminum of the first layer. The When read in its entirety, claim 35 clearly recites forming a second layer comprising an alloy of titanium and aluminum formed from at least one of elemental titanium or a titanium alloy and the aluminum from the first layer. The titanium recited at line 13 and 16 which is comprised by an aluminum titanium alloy, does not limit the recitation of at least one of elemental titanium or titanium alloy recited in lines 9-10. Claim 35 is therefore not rendered unclear by such recitations.

The Examiner extends the rejection of independent claim 35 to dependent claims 36-48 for depending from an unclear base claim. Dependent claims 36-48 are not rendered unclear by the recitations of base claim 35 for the reasons discussed above.

The lack of clarity rejection as discussed above with respect to independent claim 35 has been extended to independent claim 58 and claims 59-74 which depend therefrom. Independent claim 58 recites depositing at least one of elemental titanium or a titanium alloy on an aluminum comprising layer and forming therefrom a second layer comprising an alloy of titanium and the aluminum from the first layer. The recitation of claim 58, when read as a whole,

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is not unclear and is allowable for reasons similar to those discussed above with respect to claim 35. Dependent claims 59-74 are similarly not rendered unclear by the recitation of their base claim 58.

With respect to claim 38, the Examiner states that such claim is "somewhat redundant" because an aluminum alloy is an inherent mixture of aluminum and that recitation of a mixture is not different from an aluminum alloy which is a mixture of aluminum. The Examiner is mistaken. Applicant directs attention to applicant's disclosure at page 7 lines 6-17. Such disclosure describes forming a layer 42 by a first deposition and a second deposition. The first deposition deposits at least one of elemental aluminum or an aluminum alloy over a substrate. The second deposition deposits aluminum at a higher temperature. Applicant notes that a mixture of elemental aluminum and aluminum alloy can be formed in accordance with the disclosure by, for example, depositing elemental aluminum in the first deposition and depositing an aluminum alloy in the second, higher temperature, deposition. Contrary to the Examiner's statements, the recitation in claim 38 of a first layer which consists of a mixture of elemental aluminum and an aluminum alloy is not synonymous with an aluminum alloy. Similar reasoning applies to claim 69 to which the Examiner has extended a similar rejection. Accordingly, applicant respectfully requests withdrawal of the rejection of claim 38 and 69 based on redundancy.

With respect to dependent claim 41, the Examiner states that such claim is out of the scope of independent claim 35. The Examiner states that claim 35 recites maintaining the temperature of at least 360° C during deposition and

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recites a minimum temperature of at least 400 °C while the limitation of claim 41 is below the lower limit of independent claim 35, rendering the scope of the claims indefinite. Applicant disagrees with the Examiner's statements. First, with respect to independent claim 35, such recites depositing a first layer at a first deposition temperature of at least 400 °C (lines 5-6) and, in a second chamber, depositing at least one of elemental titanium or titanium alloy while at least an outer portion of the first layer is at a temperature of at least 360 °C. Dependent claim 41 recites a temperature of at least the outer portion of the first layer being at least about 360 °C during the physical vapor deposition of a third layer. Independent claim 35 does not recite a temperature limitation during the physical vapor depositing of a third layer. Dependent claim 41 is therefore not outside the scope of independent claim 35. Accordingly, applicant respectfully requests withdrawal of the Examiner's rejection of claim 41 based on indefinite claim scope.

Claims 35-74 each stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the combination of Besser, U.S. Patent No. 5,582,881; Shan, U.S. Patent No. 6,140,228; Colgan, U.S. Patent No. 5,925,933 and Marieb, U.S. Patent No. 5,909,639. A proper obviousness rejection has the following three requirements: 1) there must be some suggestion or motivation to modify or combine reference teachings; 2) there must be a reasonable expectation of success; and 3) the prior art references as combined must teach or suggest each and every claim limitation (MPEP § 2143). Each of claims 35-74 are allowable over the combination of Besser, Shan, Colgan and Marieb for at least

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the reason that the references, either independently or as combined, fail to teach or suggest each and every limitation in any of those claims.

With respect to independent claim 35, such recites depositing a first layer that comprises at least one of elemental aluminum or an aluminum alloy at a deposition temperature of at least 400 °C and, without letting the outermost portion of the first layer cool below a temperature of 360 °C, depositing titanium or a titanium alloy to form a second layer comprising an alloy of titanium and the aluminum from the first layer. Claim 35 further recites that the alloy of titanium and aluminum is formed during the depositing of the at least one of elemental titanium or a titanium alloy. Besser discloses a process of depositing a titanium layer followed by depositing a titanium nitride layer on a sample. The process disclosed by Besser teaches a preheating step wherein a sample that could comprise an aluminum layer is preheated to a suitable temperature between 25 °C and 450 °C prior to deposition of titanium (col 3, line 60 through col 4, line 2). The Besser disclosure does not teach or suggest the recited deposition of aluminum at a temperature of at least 400 °C and, without letting the outermost portion of the aluminum comprising layer cool below a temperature of 360 °C, depositing titanium or a titanium alloy to form an alloy of titanium and aluminum from the aluminum comprising layer during the titanium deposition.

Shan discloses depositing aluminum or other metal by cold depositing a seed layer of the metal and subsequently slow-hot depositing an additional quantity of the same metal which may subsequently be followed by a rapid-hot deposition of the same metal (col 6, lines 31-37; col 7, lines 16-17; col 8, lines

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41-44 and example 1). Shan does not teach or suggest the claim 35 recited depositing aluminum or aluminum alloy layer at a temperature of at least 400 °C and, without letting the outermost portion of the aluminum comprising layer cool to below a temperature of 360° C, depositing titanium or a titanium alloy to form a titanium/aluminum alloy with aluminum from the aluminum comprising layer.

Marieb discloses depositing an aluminum-copper layer over a barrier layer, depositing a layer of titanium followed by a layer of nitride over the aluminum copper layer (col 3, lines 3-16). Subsequently, an additional titanium layer is deposited over the previously deposited layers and heat is applied to achieve the desired titanium/aluminum alloy formation (col 3, lines 23-34). Marieb does not teach or suggest the recited deposition of aluminum or an aluminum alloy at a temperature of at least 400 °C and, without letting the outermost portion of the aluminum comprising layer cool to below a temperature of 360 °C, depositing titanium or titanium alloy to form a titanium/aluminum alloy during the titanium deposition.

Colgan discloses depositing a layer of titanium followed by a layer of aluminum/copper, followed by a layer of titanium, followed by a layer of titanium nitride to form a composite-metal layer. Colgan further discloses a subsequent anneal of the composite-metal layer to react the titanium with the aluminum to form $TiAl_3$ (col 2, line 62 through col 3, line 7; and col 5, lines 20-33). Colgan does not teach or suggest the recited deposition of aluminum at a temperature of at least 400 °C and, without letting the outermost portion of the aluminum comprising layer cool to a temperature below 360 °C, depositing titanium or a

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titanium alloy to form a titanium/aluminum alloy during the titanium deposition. Besser, Shan, Marieb and Colgan, considered individually or as combined, fail to teach or suggest the claim 35 recited deposition of aluminum at a temperature of at least 400 °C and, without letting the outermost portion of the aluminum comprising layer cool to a temperature below 360 °C, depositing at least one of titanium or a titanium alloy to form a titanium/aluminum alloy during the titanium deposition. Independent claim 35 is therefore not rendered obvious by Besser, Shan, Marieb and Colgan and is allowable over this combination of references.

Dependent claims 36-48 are allowable over the combination of Besser, Shan, Marieb and Colgan for at least the reason that they depend from allowable base claim 35.

Independent claim 49 and independent claim 58 each recite depositing an aluminum comprising layer at a deposition temperature of at least 400° C and, without letting the outermost portion of the aluminum comprising layer cool to below a temperature of 360° C, depositing titanium onto the aluminum comprising layer to form an aluminum/titanium alloy during the titanium deposition. Independent claims 49 and 58 are allowable over the combination of Besser, Shan, Marieb and Colgan for at least reasons similar to those discussed above with respect to independent claim 35.

Dependent claims 50-57 and dependent claims 59-74 are allowable over the cited combination of Besser, Shan, Marieb and Colgan for at least the reason that they depend from the corresponding allowable base claims 49 and 58.

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Claims 35-74 stand rejected under the judicially created doctrine of obviousness-type double patenting over applicant's U.S. Patent No. 6,224,942 in view of Besser, or in view of Shan. Applicant hereby submits a terminal disclaimer obviating such rejection. Accordingly, applicant respectfully requests withdrawal of the double patenting rejection of claims 35-74 in the Examiner's next action.

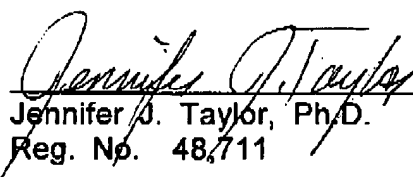
For the reasons discussed above, claims 35-74 are allowable. Accordingly, applicant respectfully requests formal allowance of claims 35-74 in the Examiner's next action.

In addition to the claim-related issues discussed above, the Examiner states that appropriate correction of the specification is required to reflect the status of the parent application and to bring the Abstract into compliance with the 150 word limit. Applicant has appropriately amended the Related Patent Data section and the Abstract as required. Accordingly, applicant respectfully requests withdrawal of the objections to the specification in the Examiner's next action.

Respectfully submitted,

Dated: 3-19-2002

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Application Serial No. 09/785,858
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Inventor Leiphart, S.
Assignee Micron Technology, Inc.
Group Art Unit 1753
Examiner Cantelmo, G.
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Title: Method of Forming an Aluminum Comprising Line Having a Titanium Nitride
Comprising Layer Thereon

**VERSION WITH MARKINGS TO SHOW CHANGES MADE ACCOMPANYING
RESPONSE TO DECEMBER 31, 2001 OFFICE ACTION**

In the Specification

The replacement specification paragraphs incorporate the following amendments. Underlines indicate insertions and ~~strikeouts~~ indicate deletions.

The Related Application Data section beginning on page 1, has been amended as follows:

This patent resulted from a continuation application of U.S. Patent Application Serial No. 09/378,651, filed August 19, 1999, which issued as U.S. Patent No. 6,224,942 on May 1, 2001 ~~entitled "Method of Forming an Aluminum Comprising Line Having a Titanium Nitride Comprising Layer Thereon", naming Shane P. Leiphart as inventor, the disclosure of which is incorporated by reference.~~

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The Abstract has been amended as follows:

The invention includes methods of forming aluminum containing lines having titanium nitride layers thereon. In one aspect, a first layer containing aluminum or an aluminum alloy is formed over a substrate. A second layer is formed containing an alloy of titanium and the aluminum of the first layer. A third layer including titanium nitride is formed and the first, second and third layers are formed into a conductive line. In one aspect, an aluminum containing line is formed utilizing physical vapor deposition of a first layer that contains aluminum or an aluminum alloy. A second layer containing an alloy of titanium and the aluminum of the first layer is formed by physical vapor depositing titanium or a titanium alloy. A third layer containing titanium nitride is formed and the first, second and third layers are photopatterned into a conductive line. ~~The invention includes methods of forming aluminum containing lines having titanium nitride containing layers thereon and preferably by physical vapor deposition. In one aspect, a first layer including at least one of elemental aluminum or an aluminum alloy is formed over a substrate. A second layer including an alloy of titanium and the aluminum from the first layer is formed. The alloy has a higher melting point than that of the first layer. A third layer including titanium nitride is formed over the second layer. The first, second and third layers are formed into a conductive line. In one aspect, a method of forming an aluminum containing line having a titanium nitride containing layer thereon includes physical vapor depositing a first layer having at least one of elemental aluminum or an~~

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~~aluminum alloy over a substrate. At least one of elemental titanium or a titanium alloy is physical vapor deposited on the first layer, and formed therefrom is a second layer comprising an alloy of titanium and the aluminum from the first layer. The alloy has a higher melting point than that of the first layer. A third layer comprising titanium nitride is physical vapor deposited over the second layer. The first, second and third layers are photopatterned into a conductive line.~~

In the Claims

The claims have been amended as follows. Underlines indicate insertions and ~~strikeouts~~ indicate deletions.

35. (Amended) A method of forming an aluminum comprising line having a titanium nitride comprising layer thereon, the method comprising:

in a processing tool, physical vapor depositing a first layer comprising at least one of elemental aluminum or an aluminum alloy over a substrate in a first chamber, at least an outermost portion of the first layer being deposited at a first deposition temperature of at least 400°C;

after the first layer physical vapor depositing and without letting the outermost portion of the first layer cool from the first deposition temperature to a temperature below 360°C, physical vapor depositing at least one of elemental titanium or a titanium alloy on the first layer in a second chamber of the processing tool while at least an outer portion of the first layer is at a

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temperature of at least about 360°C, and forming therefrom a second layer comprising an alloy of titanium and the aluminum from the first layer in the second chamber during said depositing, the alloy having a higher melting point than that of the first layer, and wherein essentially all the physical vapor deposited titanium alloys with the aluminum of the first layer;

physical vapor depositing a third layer comprising titanium nitride on the second layer ~~in the second chamber of the processing tool~~;

removing the substrate from the processing tool after depositing the third layer; and

forming first, second and third layers into a conductive line.

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